1024-Pos Board B810
Biogenic Silica Nanopore Membranes on Micromachined Silicon Substrates
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Nanopore membranes are extremely valuable for applications such as molecular filtration, nanoparticle counting, and sizing studies. However, the fabrication of nanopore membranes using top-down silicon microfabrication technology requires using slow serial patterning processes, making it unsuitable for large-scale manufacturing. Marine diatoms on the other hand feature biomineralized silica shells with the smallest pore diameters on the order of 40 nm. Their hierarchical pore architecture makes these nanomembranes exceptionally mechanically stable, while maintaining a short pore length and a high porosity.
In our study, we immobilized the biogenic silica nanomembranes on micromachined silicon substrates. These substrates feature micron-sized, through-wafer channels, enabling free fluidic access to the nanopore membrane. The diatom shells were mounted on top of the silicon microstructure using either poly-L-lysine or UV-polymerizable low-stress epoxy. The resulting microsystem allowed easy handling and mounting in a fluidic platform for nanoparticle transport studies.
Using fluorescent nanoparticles we were able to verify that particles with a diameter larger than that of the nanopores were completely retained, while smaller particles, such as polystyrene beads or gold nanoparticles did permeate through the membrane. No evidence for leakage around the diatom was observed, indicating a successful seal around the perimeter of the membrane. When the particles passed through the membrane, the temporary blockage resulted in a reduction in ionic current corresponding to the ratio between the bead and pore size. The characteristic electrophoretic mobility of the beads allowed a characterization of nanoparticles of different origin. The large number of nanopores available for particle translocation (>200) makes them ideal size-selective filters with a low probability of clogging. The combination of biomineralized and microfabricated structures shows a pathway for integrating low-cost nanostructures with BioMEMS devices.

1025-Pos Board B811
Ionic Liquids Transport through Single Nanopores
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Room temperature ionic liquids are media consisting only of ions and are liquids at temperatures below 100 C. Constituent ions of ionic liquids are bulky and reach a size of 1 nm and larger. The finite size of the ions, which often is comparable to the diameter of the nanopores through which they get transported, makes application of classical electrochemical and electrostatic theories questionable. It is because the existing continuum theories for simplicity treat ions as point charges. A similar situation of a tight fit between transporting ions and pore diameter exists in the biological channels of a cell membrane.
Using single nanopores prepared in polyethylene terephthalate (PET) by the track-etching technique, we investigated how ion current through nanopores and screening of surface charges on the pore walls were influenced by the size of the transported ions. Experiments were performed with aqueous solutions of KCl and the ionic liquids 1-Butyl-3-methylimidazolium methyl sulfate and 1-butyl-3-methylimidazolium chloride.
The screening was evaluated using the rectification properties of homogeneously charged nanopores, as well as pores with a surface charge pattern that enables them to function as ionic diodes. Interactions of ions with surface charges were also described using reversal potential measurements in conjunction with Goldman Katz theory. Our experiments indicate that aqueous solution of ionic liquids screen surface charges over smaller distances than KCl.

1026-Pos Board B812
Salt Gradient Enhances Small Molecules Capture in a Biological Nanopore
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Nanopore based sensors promise ultrasensitive detection of an array of nucleic acid, peptide, and protein biomarkers. However, the low physiological concentrations of cancer biomarkers can greatly limit their detection in conventional nanopore sensors due to the low trapping rate of these markers inside of the nanopore. A previous study used a salt gradient to generate an enhanced electric field (EEF) in a synthetic nanopore, which increased the capture rate of double-stranded DNA. In this study, we have demonstrated that the use of an EFF in a biological pore can lead to dramatic increases in the trapping frequency of single stranded DNA (~80x), double stranded DNA (~30x), peptides (~15x) and DNA-protein complex (~30x). We then provide evidence that this increase of trapping frequency is directionally and molecularly-dependent. Finally, picogram level of liver-specific microRNA was successfully detected in the pore using this salt gradient.

1027-Pos Board B813
Oligomer Duplex Tearing and Shearing Mechanisms in the Nanopore
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The nanopore has been developed as a molecule force microscope to explore the dissociation of oligomer duplex, such as the double-stranded DNA/RNA and hairpin duplexes, or DNA-RNA hybrids. The oligomer duplexes can be trapped in the nanopore can generate long current blocks. By measuring the voltage-dependent block duration, the unzipping kinetics as well as the force and energy involved in the double strands hybridization can be characterized. However, few studies have presented convincing characteristic current patterns for the dissociation occurrence. In this report, we uncovered signature current patterns that can electrically track the dissociation processes in tear and shear geometry, from the time course of dissociation to the motion pathway of the unzipped single-stranded DNA. With the signature signals, the duplex trapping-unzipping, and trapping-escaping without unzipping as well as trapping directionality can also be distinguished. Quantitative analysis of signature signals showed that the oligomer duplex with a single-stranded overhang is more easily to be trapped in the nanopore compared to the blunt-ended duplex. Therefore the overhang is not only an unzipping driver, but also a controller of DNA trapping orientation, regulating the duplex dissociation in a programmable manner. Discrimination of duplex dissociation signatures not only gives precise insight into the dissociation mechanisms, but more importantly in biosensors for detection of disease-related biomarkers. These dissociation signatures can serve as a single-molecule elecrical marker that ensures both selectivity and sensitivity.

1028-Pos Board B814
Computational Investigation of Graphene Nano Pore DNA Detection
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Recently, voltage-induced transport of dsDNA molecules through nano pores in graphene membranes has been demonstrated experimentally. Graphene, due to its sub-nanometer thickness, shows great potential to realize DNA sequencing at single-base resolution. The kinetics of electrophoretically driven DNA translocation through graphene nanopores was studied using molecular dynamics simulations (Sathe et al., ACS Nano, in press). The simulations provide guidance in the design of graphene-based DNA sequencing devices and single molecule sensors. We report the effects of applied voltage, DNA conformation, pore charge as well as sequence on the translocation characteristics of DNA revealed in the simulations. Simulations yield also, consistent with recent measurements, the characteristics of ion currents passing pores alongside with DNA. The simulations demonstrate, furthermore, that under suitable voltage bias conditions A-T and G-C base pairs can be discriminated using graphene nanopores.

1029-Pos Board B815
Determining Optimal Voltage Inputs For Exonuclease I Experimentation from Single-Abasic DNA Strands Captured in a Nanopore
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Nanopores are a powerful technology for detecting DNA-enzyme interactions on the single-molecule level. A voltage is used to apply force to hold the DNA-enzyme complex on the pore during measurements, and also to generate the measurement current that signals changes in the complex on the pore. We are interested in finding the ''minimal'' voltage as the one that generates sufficient signal-to-noise ratio (SNR) for detecting complex changes, with the smallest force required. We explore the sensitivity of an α-Hemolysin nanopore by capturing 20 different single-stranded homopolymers (poly-C), each with a single abasic element at different locations on the DNA strand. For each strand that we captured on the pore, we applied a voltage titration from 120 mV down to 10 mV, decrementing in 10 mV intervals. With the voltage